Abstract Submitted
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Toward understanding the mechanics of hovering in insects, hummingbirds and bats HAMID VEJDANI, School of Engineering, Brown University, Providence, RI, DAVID BOERMA , SHARON SWARTZ , Department of Ecology and Evolutionary Biology, Brown University, Providence, RI, KENNETH BREUER , School of Engineering, Brown University, Providence, RI — We present results on the dynamical characteristics of two different mechanisms of hovering, corresponding to the behavior of hummingbirds and bats. Using a Lagrangian formulation, we have developed a dynamical model of a body (trunk) and two rectangular wings. The trunk has 3 degrees of freedom (x, z and pitch angle) and each wing has 3 modes of actuation: flapping, pronation/supination, and wingspan extension/flexion (only present for bats). Wings can be effectively massless (hummingbird and insect wings) or relatively massive (important in the case of bats). The aerodynamic drag and lift forces are calculated using a quasi-steady blade-element model. The regions of state space in which hovering is possible are computed by over an exhaustive range of parameters. The effect of wing mass is to shrink the phase space available for viable hovering and, in general, to require higher wingbeat frequency. Moreover, by exploring hovering energy requirements, we find that the pronation angle of the wings also plays a critical role. For bats, who have relatively heavy wings, we show wing extension and flexion is critical in order to maintain a plausible hovering posture with reasonable power requirements. Comparisons with biological data show good agreement with our model predictions.

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